Topic: Cryomodule

"Options for a Highly Reliable Spoke Linac"

J-L. Biarrotte – IPN Orsay

PDS-XADS

EURISOL

Division Accélérateurs

CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

IN2P3

INSTITUT NATIONAL DE PHYSIQUE NUCLÉAIRE ET DE PHYSIQUE DES PARTICULES

About the reliability issue

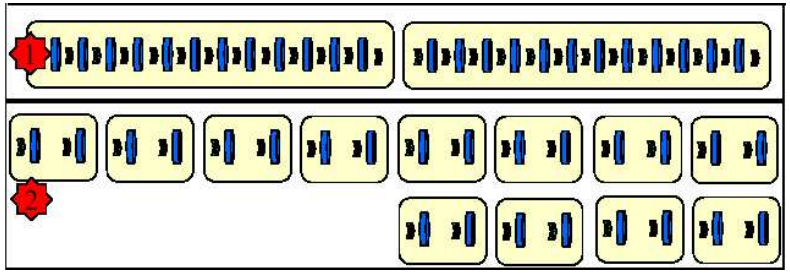
XADS linac specifications: less than 5 beam trips (>1s) per year !!!

- **Over-design** and **redundancy** are very important criteria to follow in the linac design
- **High accessibility** is required for repairing or substitution “on-line”, without interrupting the beam
- The linac must tolerate the failure of most of the components**: a “fault-tolerant” design** has to be ensure whenever possible…

Basic choices for a reliable & fault-tolerant design

- **Focusing design**

  ⇒ **Small independent modules**: lattice length continuity, modularity, simplicity



  ⇒ **SC quadrupole doublets:** more matching capability than solenoids

- **Cavities**

  ⇒ **small number of gaps (2):** higher energy acceptance, higher capability for fault-tolerance, simplicity

- **Beam dynamics**

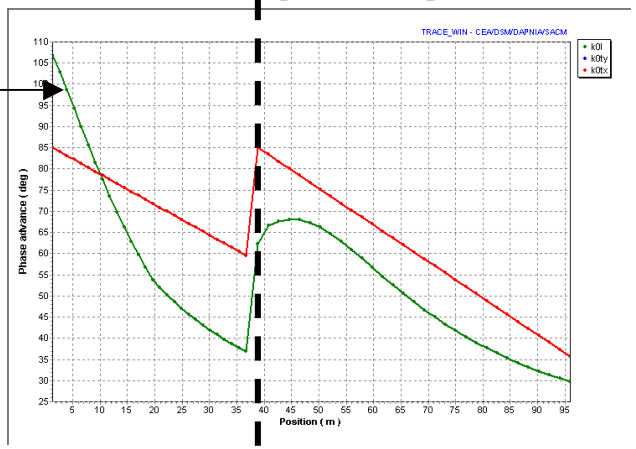
  ⇒ **Capture at 5 MeV**: synchronous phase ramped from –65° to –30°

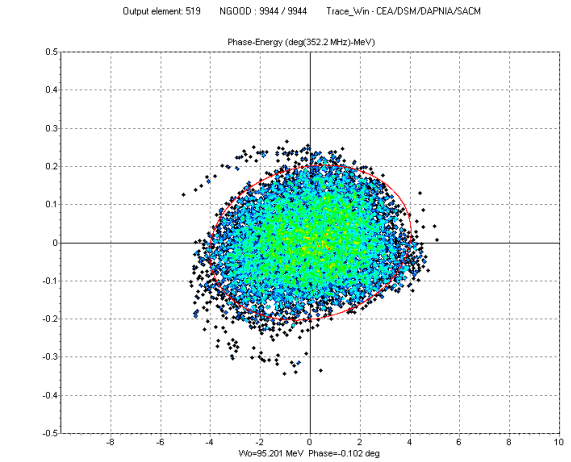
  ⇒ **Limit the accelerating gradient (thus σ) per focusing lattice:** 2-gap is far enough, and 1 (resp. 2) cavity per focusing lattice in the β=0.15 (resp. 0.35) section

& even the 2-gap case needs gradient limitations…

Phase advances per focusing lattice

Without limiting Eacc (Epk=25MV/m)

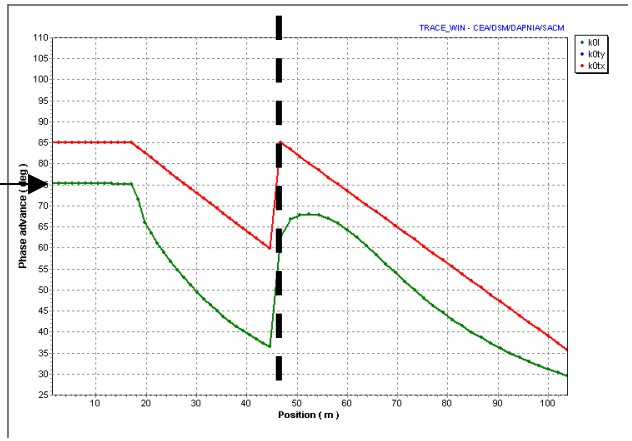


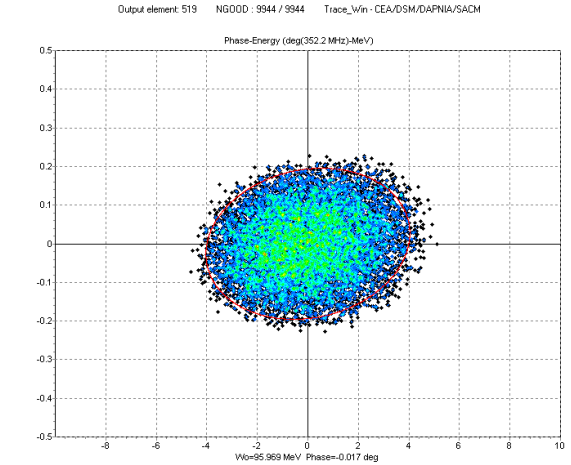


β=0.15 section
1 cav./lattice

β=0.35 section
2 cav./lattice

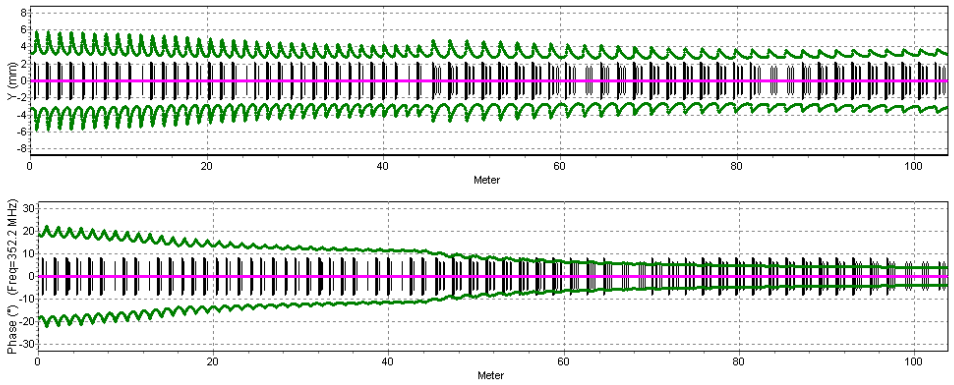
Limiting Eacc

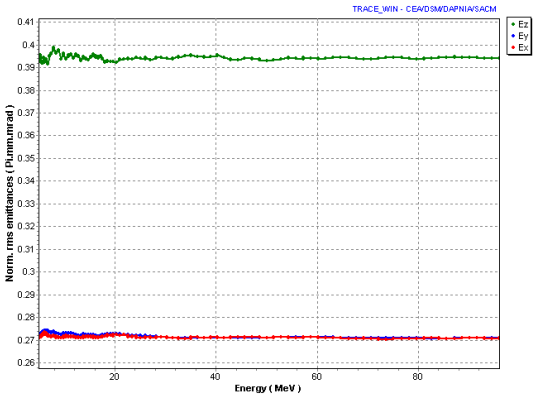




Proposal for a 5-95 MeV Spoke Proton Linac

Beam intensity: 10 mA CW	**"β=0.15" section**	**"β=0.35" section**
Energy range (MeV)	**5 – 17**	**17 – 95**
# Cavities	**34**	**62**
# Cavities per focusing lattice	**1**	**2**
Focusing lattice length (m)	**1.3**	**1.9**
Synchronous phase	**- 65° to - 30°**	**- 30°**
Energy gain per real meter (MeV/m)	**0.06 – 0.38**	**0.31 – 1.58**
Beam loading RF power (kW/cavity)	**0.8 – 5.0**	**4.1 – 15.0**
Quadrupole gradient (T/m)	**17 – 24**	**24 – 35**
Overall length (m)	**44.2**	**58.9**

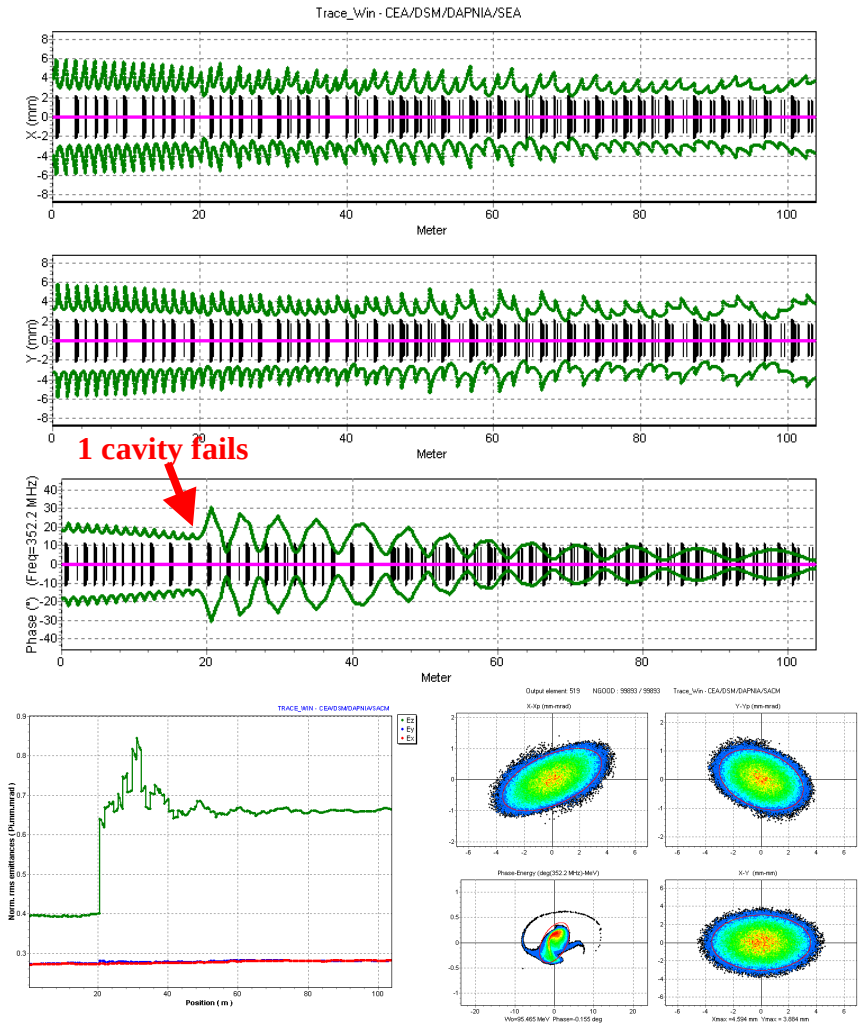




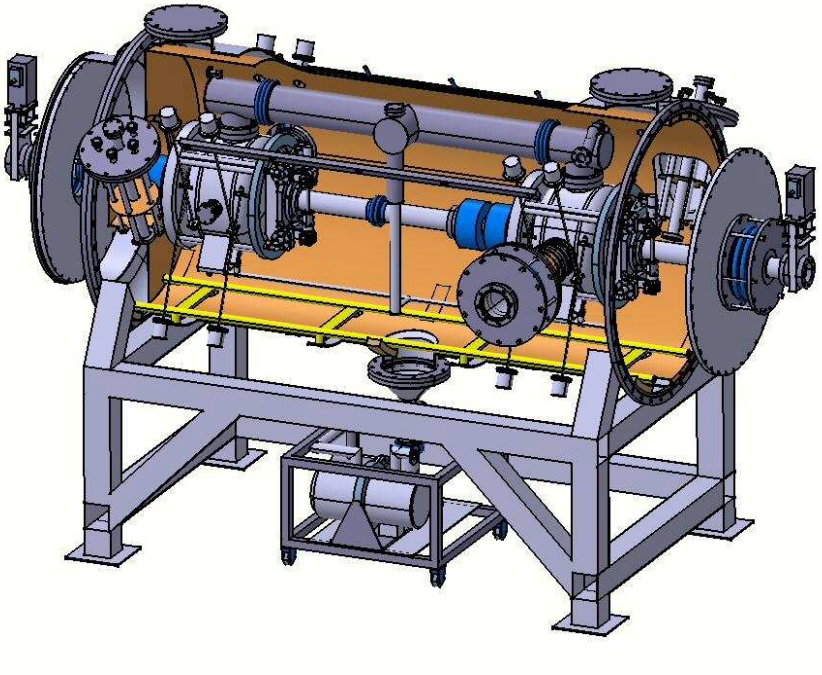
Advantages towards the reliability issue

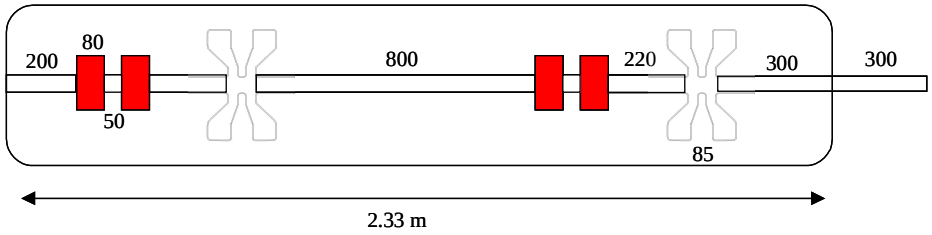
- 2-gaps cavities, independently powered
- Large beam apertures (>50mm)
- Very smooth and safe focusing design
- Modular & simple structures
- Possibility of intrinsically redundant design
- Fault tolerance capability

BUT… not very efficient in terms of real gradient between 5 & 25 MeV (β=0.15 section)



β=0.15 Spoke Cryomodule Prototyping (1)

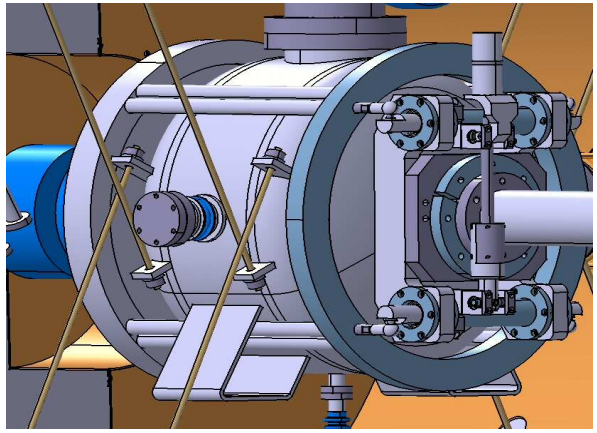


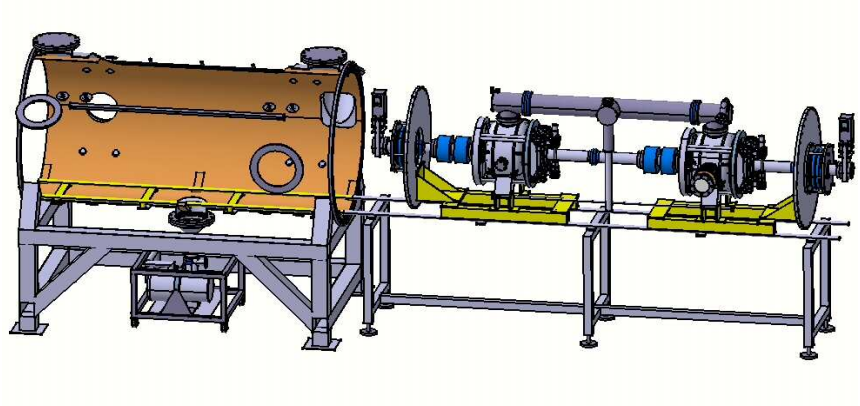


- 2.4 m long & 1 m diameter
- Including two 350 MHz spoke cavities
- Classical 4 K, 1 atm He bath
- Independent RF powering (≤5kW/cavity) using coaxial lines
- Focusing using two SC quadrupole doublets

SC « superferric » quadrupole (MSU-LNL)

β=0.15 Spoke Cryomodule Prototyping (2)





- **Cold Tuning System**: "SOLEIL-like"; efforts are applied on the flanges via Ti rods
- **Alignment** possible from the outside using 8 epoxy supports
- **Assembly**: 2 options are foreseen (whole mounting in a clean room or not)
- **Thermal shielding**: 2 options are foreseen (80 K circuit & multi-layer insulation)

Conclusion & perspectives

- The **preliminary design of a β=0.15 module** has began, and tries to fit with the XADS reliability requirements

- The aim = fabrication of a first prototype of cryomodule, which allows to test a few **different technological options**

The future =

- **Test with beam** (IPHI) without the need of a specific matching section
- Campaign for **testing the reliability of all the components**